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(54) **LENS HAVING DENSELY-DISTRIBUTED CONVEX FACETS ON ITS ENTRANCE AND EXIT SURFACES**

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See application file for complete search history.

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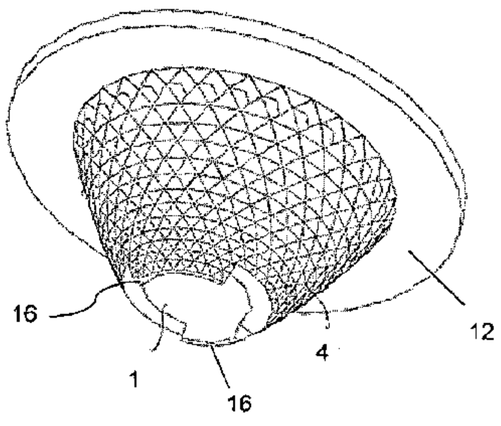
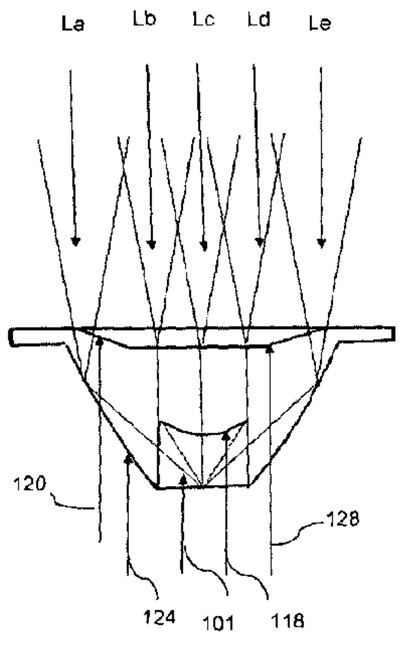
Primary Examiner — Peggy Neils

(57) **ABSTRACT**

LED-integrated lens comprising a light-entering section (**1**) in the shape of a hole, a light-emitting section (**2**) in the shape of a cup, incorporating an optical lens (**3**) positioned between said light-entering and light-emitting sections (**1**, **2**) wherein the external surfaces of the light-entering (**1**) and of the light-emitting (**2**) sections include portions having densely-distributed convex facets. This lens enhances light utilization efficiency, avoids creating spots with color aberration hence greatly improves color rendering.

20 Claims, 4 Drawing Sheets





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G02B 3/08	(2006.01)
G02B 19/00	(2006.01)
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F21V 7/00	(2006.01)
F21V 17/10	(2006.01)
F21K 9/23	(2016.01)
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F21K 9/238	(2016.01)
F21K 9/00	(2016.01)
F21V 29/00	(2015.01)
F21V 7/04	(2006.01)
F21V 29/89	(2015.01)
F21Y 101/00	(2016.01)
F21Y 115/10	(2016.01)
F21K 9/69	(2016.01)

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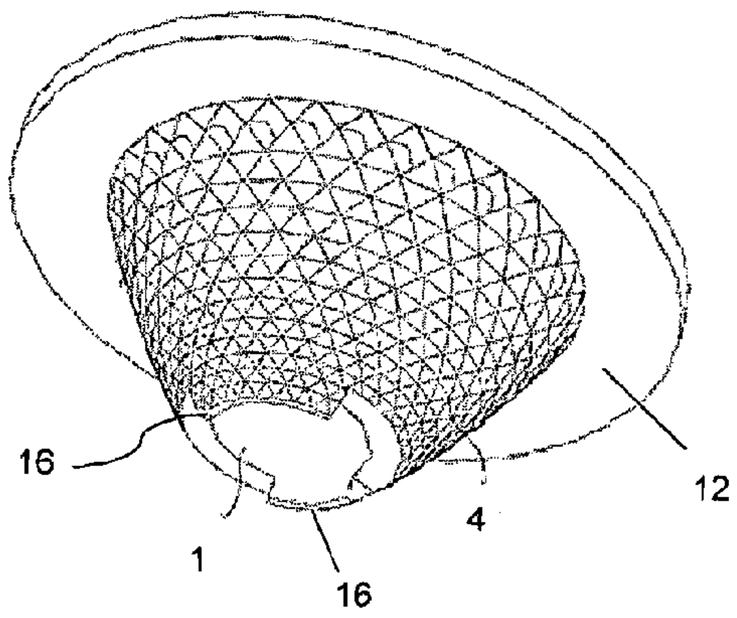


Fig.1

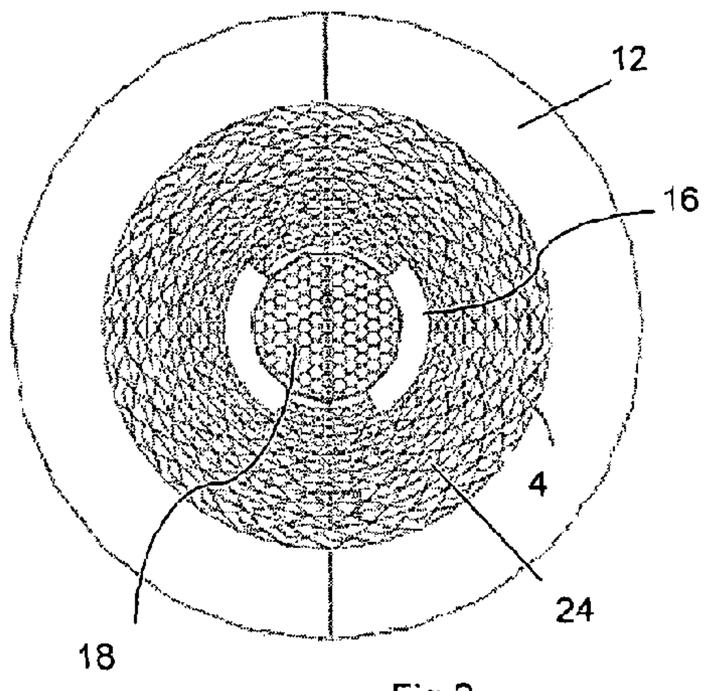


Fig.2

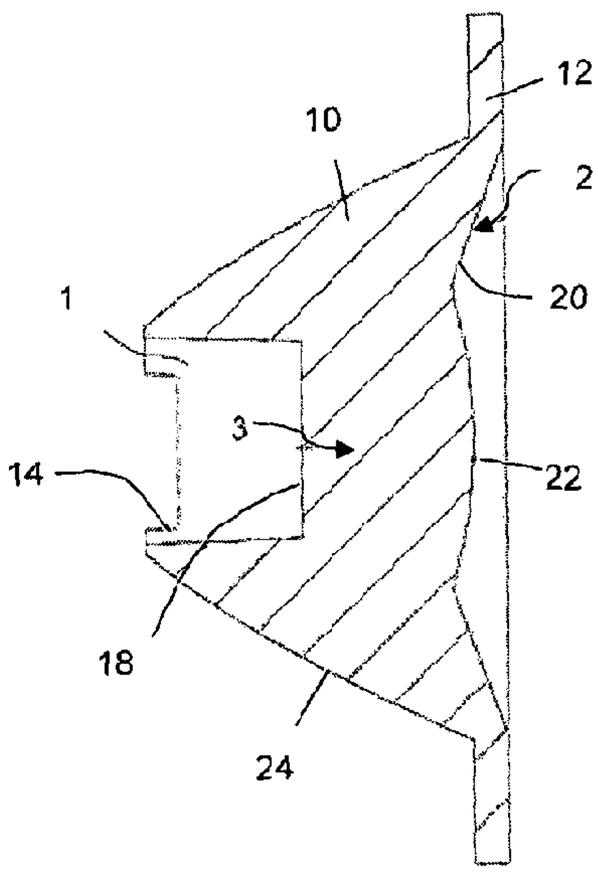


Fig.3

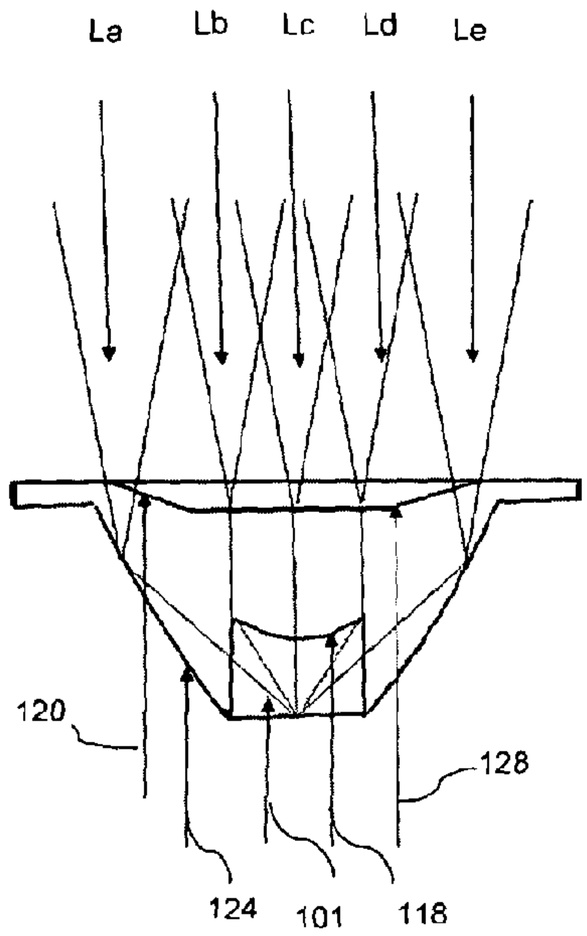


Fig.4

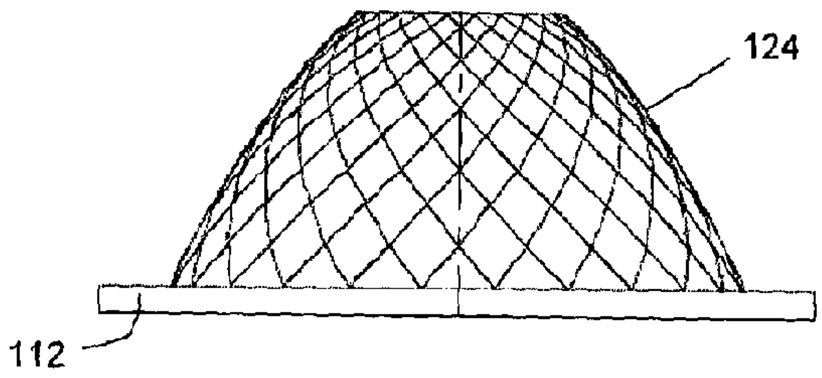


Fig.5

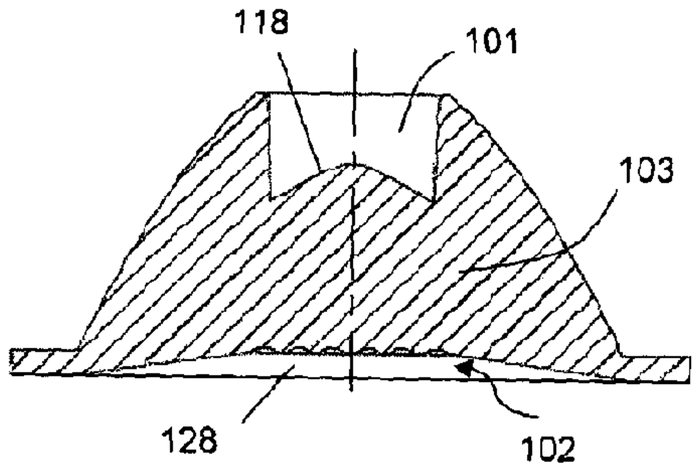


Fig.6

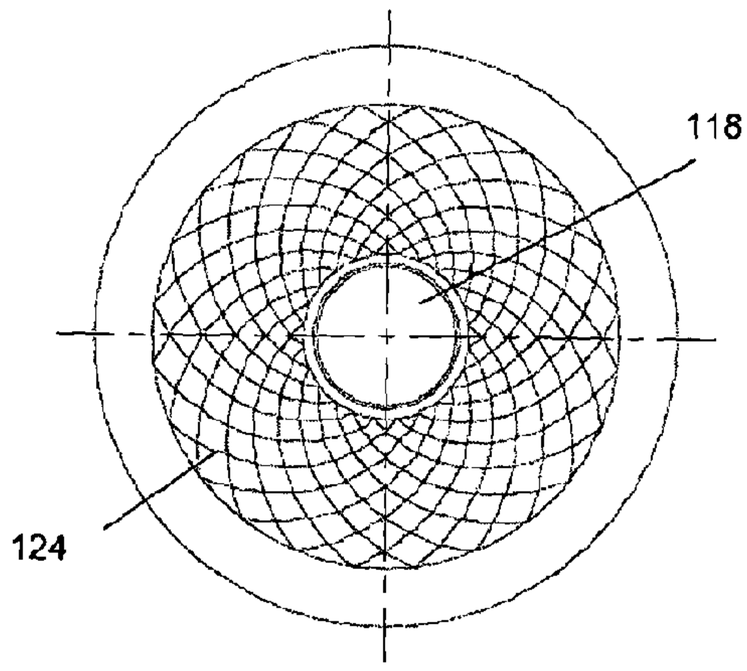


Fig.7

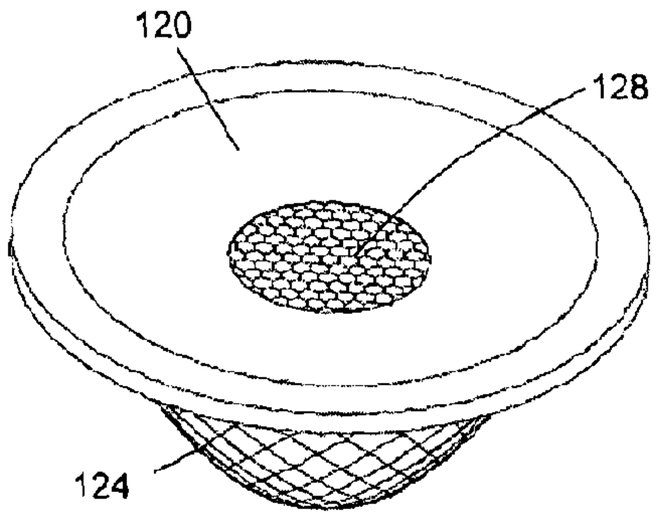


Fig.8

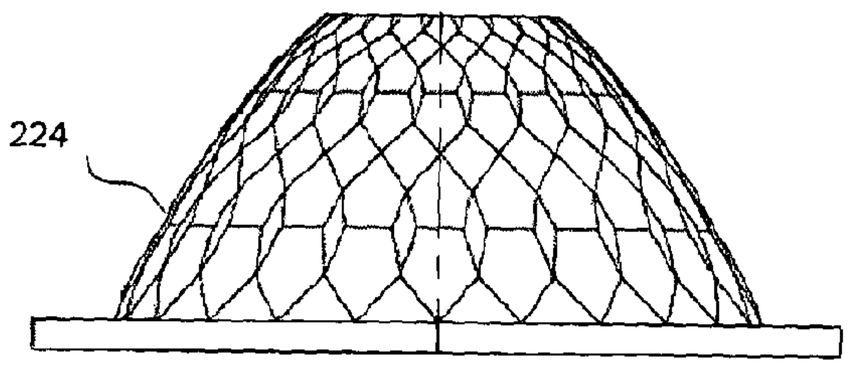
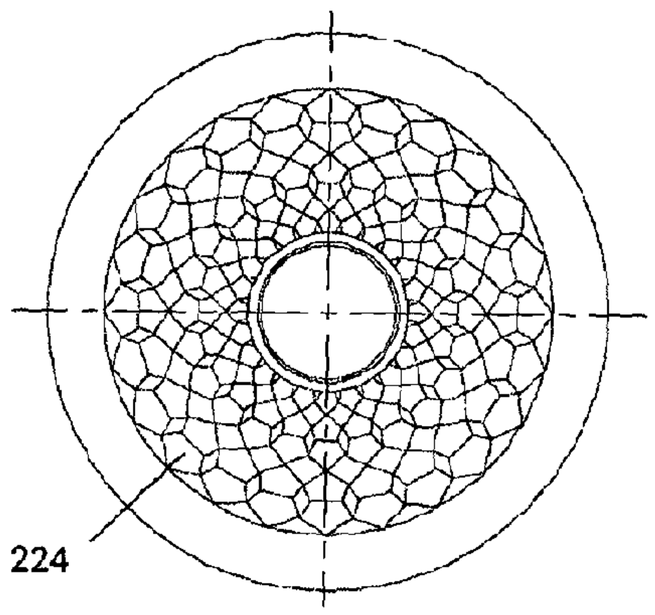


Fig.9



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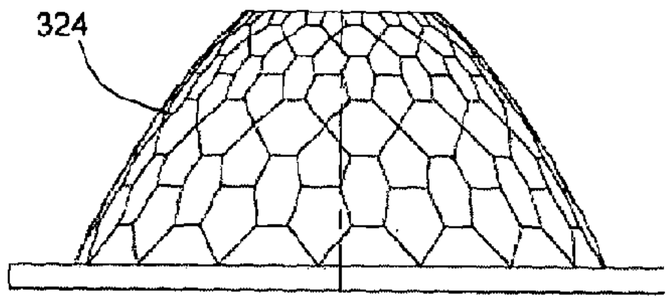


Fig.11

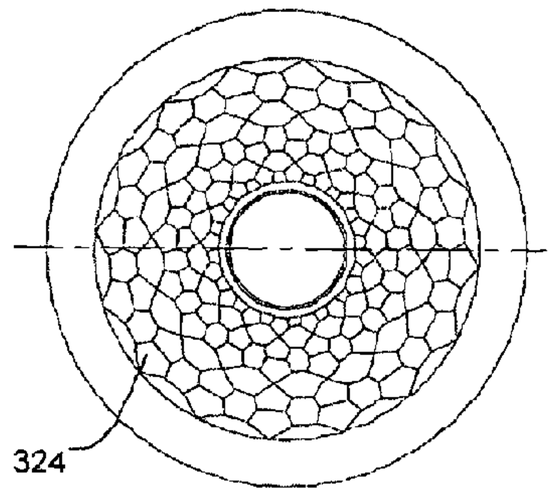
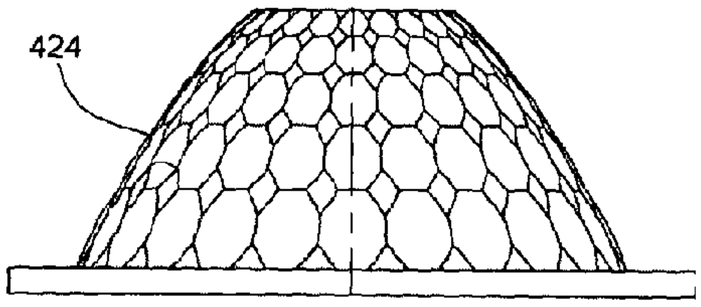


Fig.12



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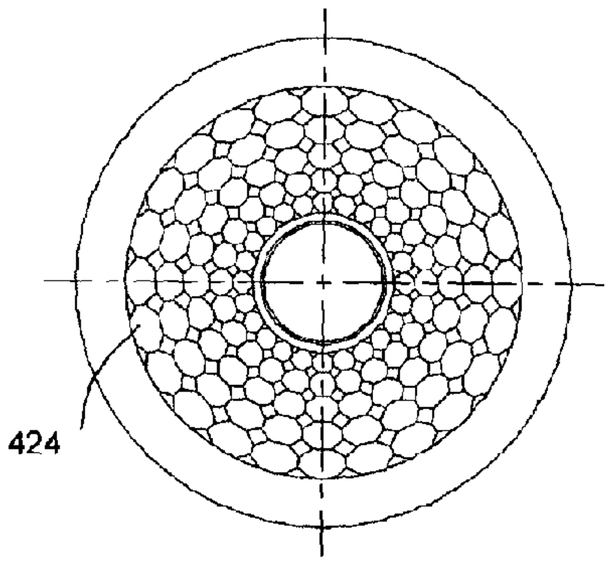

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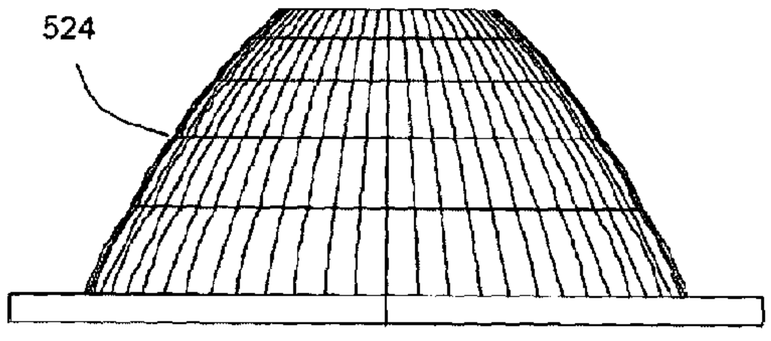

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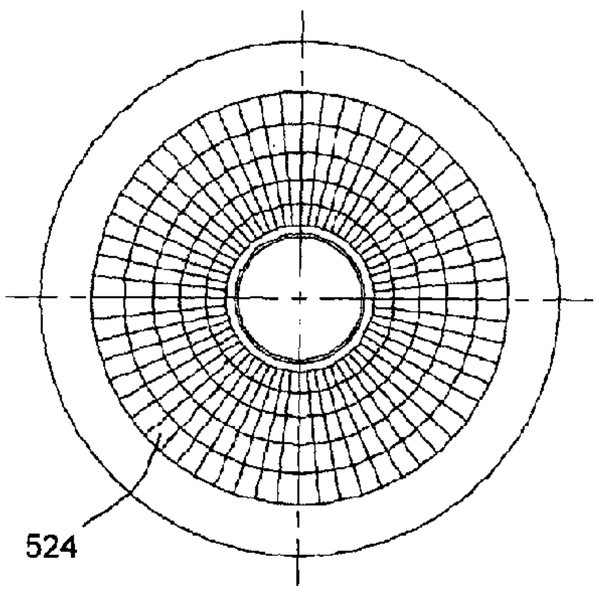

Fig.16

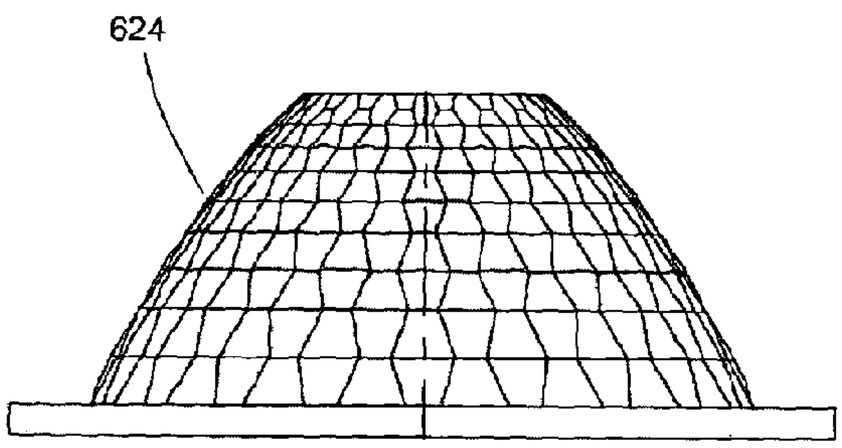

Fig.17

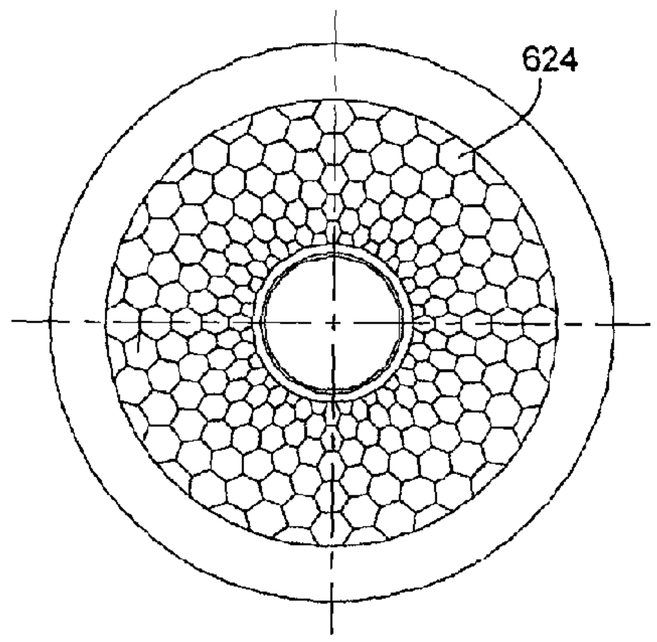

Fig.18

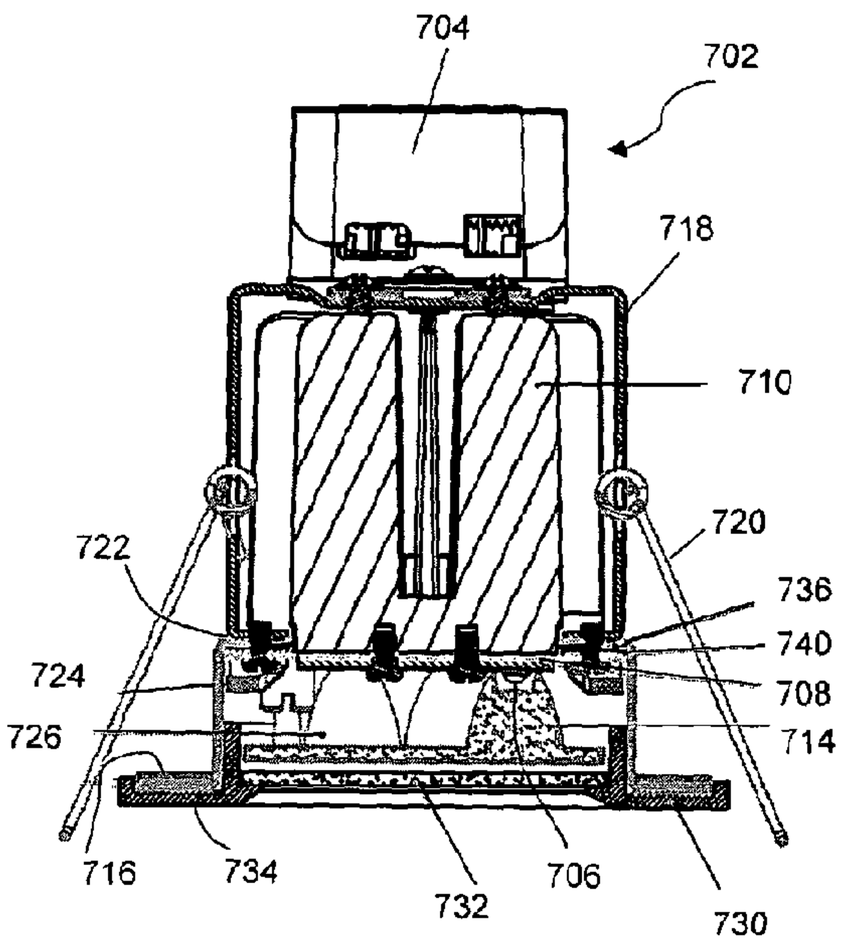

Fig. 19

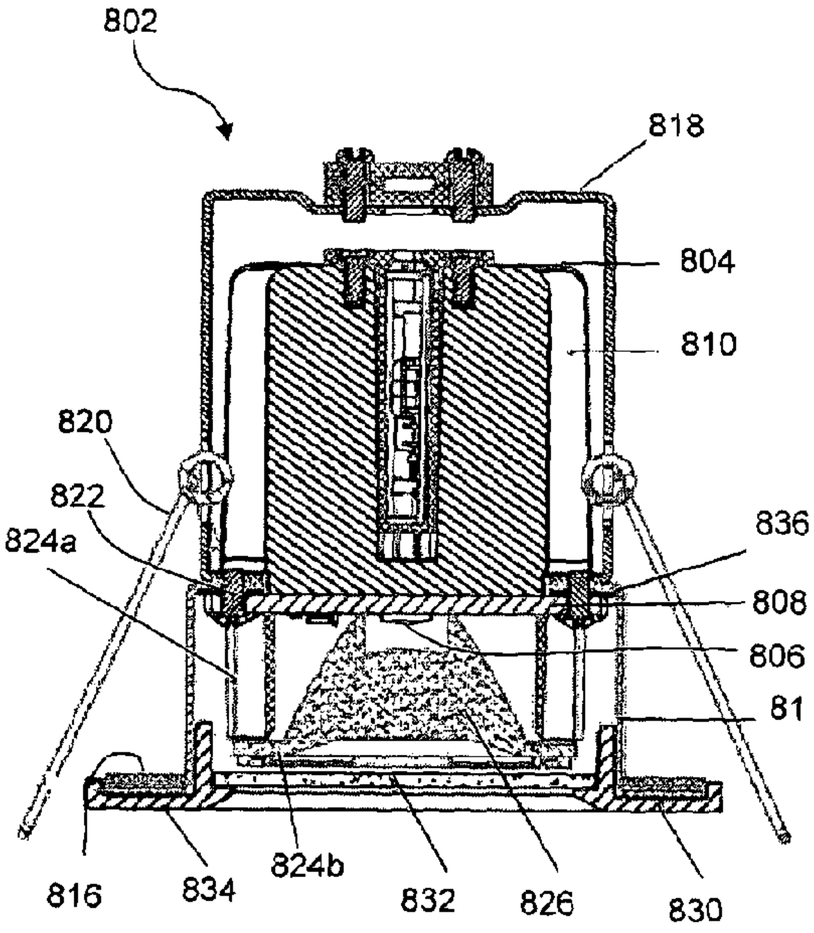

Fig. 20

LENS HAVING DENSELY-DISTRIBUTED CONVEX FACETS ON ITS ENTRANCE AND EXIT SURFACES

FIELD OF THE INVENTION

The present invention relates to a new type of lens, in particular, but not exclusively, for use with an LED luminaire having an LED integrated light source.

BACKGROUND TO THE INVENTION

An LED integrated light source lens contributes to boosting the surface luminous efficiency of an LED integrated light source. An LED integrated light source lens of the known kind, comprising a light entering section in the shape of hole and of a light emitting section in the shape of a cup, has smooth surfaces on both the light entering and emitting sections. This has as a disadvantage that light utilisation efficiency of the LED integrated light source is very poor. A further disadvantage is that this arrangement creates luminous spots with obvious colour aberration, that is the colour rendering index is adversely affected.

SUMMARY OF THE INVENTION

According to the present invention an LED integrated light source lens comprising a light entering section in the shape of a hole, a light emitting section in the shape of a cup, is disclosed incorporating an optical lens positioned between the light entering section and the light emitting section, wherein the external surfaces of the light entering and emitting sections include portions having densely distributed convex facets.

Preferably, the optical lens has a spotted surface on one side.

Preferably, the optical lens has a curved surface on the other side.

Preferably, the curved surface is convex.

Preferably, the hole is provided with a non-spherical surface at its base

This construction has a number of advantages. The densely distributed convex facets on the external surfaces of the light entering and emitting sections, cause the LED integrated light source to emit multi-point lights, which enhances light utilisation efficiency, creates no spot lights with colour aberration, this in turn greatly improves the colour rendering index. The side of the optical lens having a spotted surface, creates multi-point lights. The other side of the optical lens, having a curved surface, changes the light beam angle.

A further advantage is that such a lens is relatively squat allowing for the use of LED light sources together with such a lens in new applications.

According to a second aspect of the present invention a lens is provided with a plurality of light entering sections, each in the shape of a hole, a light emitting section associated with each of the light entering sections, the light emitting section being in the shape of a cup, is disclosed incorporating an optical lens positioned between each light entering section and the associated light emitting section, wherein the external surfaces of the associated light entering and emitting sections include portions having densely distributed convex facets.

According to a third aspect of the present invention, a downlight comprises a casing, a light source, a lens according to the first or second aspects of the present invention, a lens holder and a heat sink.

Preferably, the downlight further comprises a glass and retaining means for the glass.

Preferably, the light source comprises one or more LEDs mounted on a circuit board. Preferably, the circuit board may be formed of a ceramic material. Alternatively, the circuit board may be formed of aluminium and a brass or copper disc located between the circuit board and the heat sink.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described, by way of example only, in relation to the attached Figures, in which

FIG. **1** shows a schematic perspective view of a first embodiment of a lens according to the present invention;

FIG. **2** shows a view from below of the lens of FIG. **1**;

FIG. **3** shows a section along line A-A of FIG. **2**;

FIG. **4** shows a section similar to that of FIG. **3** showing schematically the flow of light through the lens;

FIG. **5** shows a side view of a second embodiment of a lens according to the present invention;

FIG. **6** shows a section along line A-A of FIG. **5**;

FIG. **7** shows a view from below of FIG. **5**;

FIG. **8** shows a perspective view of the front of FIG. **5**;

FIG. **9** shows a side view of a third embodiment of a lens according to the present invention;

FIG. **10** shows a view from below of FIG. **9**;

FIG. **11** shows a side view of a forth embodiment of a lens according to the present invention;

FIG. **12** shows a view from below of FIG. **11**;

FIG. **13** shows a side view of a fifth embodiment of a lens according to the present invention;

FIG. **14** shows a view from below of FIG. **13**;

FIG. **15** shows a side view of a sixth embodiment of a lens according to the present invention;

FIG. **16** shows a view from below of FIG. **15**;

FIG. **17** shows a side view of a seventh embodiment of a lens according to the present invention;

FIG. **18** shows a view from below of FIG. **17**;

FIG. **19** is a sectional view of a first embodiment of a down light in accordance with a second aspect of the present invention; and

FIG. **20** is a sectional view of a second embodiment of a down light in accordance with a second aspect of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to FIGS. **1** to **3**, the lens can be seen to comprise a substantially solid body **10** having a generally conical or frusto-conical portion **4** provided with a flange **12** extending thereabout providing a circular periphery to the lens. The conical or frusto-conical portion **4** extends from the circular flange **12**. The side of the flange **12** from which the conical or frusto-conical portion **4** extends will be referred to as the bottom or rear side and reference to an 'upper side', a 'front side', 'above' or 'below' should be interpreted accordingly.

The lens has a central vertical axis. The lens is formed from a transparent material. In the case of a transparent plastics material, the lens is preferably formed by injection moulding.

An upper portion of the conical or frusto-conical portion **4** is provided with a recess or hole provided therein. The hole is in the form of a blind recess. As may be seen form the figures the recess is hexagonal in section, though other

sections may be used. The side or sides of the recess are aligned with the central vertical axis.

The tip of the conical or frusto-conical portion **4** is provided with two cut away portions **14** extending along a portion of a circumference of the conical or frusto-conical portion **4** to create two tabs **16** extending inbetween. From FIG. **2**, it can be seen that the lens is symmetric about a central plane.

In use, an LED is located at the opening of the hole in the conical or frusto-conical portion **4**, such that the hole forms a light entering section **1** of the lens. A base of the hole is provided with a refractive surface **18** for example a spotted surface. In this embodiment the refractive surface **18** is circular in shape. From FIG. **2** it can be seen that this has taken the form of a hexagonal pattern of convex facets formed on the surface of the base of the hole. In use, the refractive surface **18** creates multi-point light beams. Preferably, the refractive surface **18** is a non-spherical refractive surface. In this embodiment the refractive surface **18** is located on a generally level plane.

The external surface of the conical or frusto-conical portion **4** is provided with a network of densely distributed convex facets **24**. In use, these facets **24** create multi-point light beams. The facets **24** of this embodiment can be seen to be generally triangular.

An external surface of the light entering section **1** can thus be seen to be provided with convex facets **24** on the conical or frusto-conical portion **4** and convex facets on the refractive surface **18**.

The front of the lens is provided with a shaped recess. The shaped recess is in the shape of a cup, being generally concave, comprising an inclined surface **20** extending inwardly from the front face of the lens, the inclined surface **20** meeting a generally circular base **22** of the cup shape, the base **22** being convex in shape. The curved convex shape is used to change the light beam angle. The generally circular base **22** is provided with a network of refractive surfaces in the form of densely distributed convex facets. The inclined surface is preferably concave.

In use, the shaped recess forms a light emitting section **2** of the lens.

The portion of the lens between the hole and the shaped recess forms an optical body or lens **3** positioned therebetween.

It will be understood that the light entering section **1**, the light emitting section **2** and the optical lens **3** are formed as a unitary or one piece body from the transparent material.

FIGS. **5** to **8** show a second embodiment of a lens in accordance with the present invention. It is noted that this embodiment (and those following) do not feature the cut out at the end of the conical or frusto-conical portion. Also, the hole or blind recess is circular in section.

This embodiment (and those following) is further distinguished by the pattern of the network of refractive surfaces.

Similar reference numerals are used to refer to similar aspects of the invention. Thus, a conical or frusto-conical portion of a lens is provided with a flange **112**. A light entering section **101** includes an outer surface of the conical or frusto-conical portion provided with a network of refractive surfaces **124** and a non-spherical base surface **118** provided at rear surface of the lens. The network of refractive surfaces **124** generally diamond shaped. A generally concave light emitting section **102** comprises an inclined surface **120** extending inwardly from the front face of the lens, the inclined surface **120** meeting a generally circular base, the base being provided with a network of refractive surfaces **128**. In this embodiment (and those following) the base is generally planer. An optic lens **103** is defined between the light entering section **101** and the light emitting section **102**.

The functioning of the lens is now described with reference to FIG. **4**. Light is emitted from a light source, such as an LED (not shown) and may adopt a number of paths. Light passing through the sides of the light entering section **101** will having passed through the lens encounter the network of convex facets **124**. This causes the light at the surface to form multipoint full reflection lights directed back toward the light emitting surface section **102**. The creation of multipoint full reflection lights decreases the glare index and increases the colour rendering index.

Light encountering the refractive surface **118** on the base of the hole is focussed on the network of refractive surfaces **128** on the light emitting section **102** of the lens. This improves light efficiency.

Light passing to the network of refractive surfaces **128** on the light emitting section **102** of the lens forms multi point refraction emitting light which decreases the glare index and increases the colour rendering index.

The inclined surface **120** surrounding the network of refractive surfaces on the light emitting section **102** of the lens facilitates the injection moulding process and improves product consistency.

FIGS. **9** and **10** show a third embodiment of a lens in accordance with the present invention. The third embodiment is of similar section to the second embodiment and shows a further pattern of refractive surfaces **224**, the facets comprising a mix of diamond shaped facets and pentagonal facets.

FIGS. **11** and **12** show a fourth embodiment of a lens in accordance with the present invention. The fourth embodiment is of similar section to the second embodiment and shows a further pattern of refractive surfaces **324**, the facets comprising a mix of hexagonal facets and pentagonal facets.

FIGS. **13** and **14** show a fifth embodiment of a lens in accordance with the present invention. The fifth embodiment is of similar section to the second embodiment and shows a further pattern of refractive surfaces **424**, the facets comprising a mix of diamond shaped facets and octagonal facets.

FIGS. **15** and **16** show a sixth embodiment of a lens in accordance with the present invention. The sixth embodiment is of similar section to the second embodiment and shows a further pattern of refractive surfaces **524**, the facets comprising generally rectangular facets.

FIGS. **17** and **18** show an seventh embodiment of a lens in accordance with the present invention. The seventh embodiment is of similar section to the second embodiment and shows a further pattern of refractive surfaces **624**, the facets comprising a patterning of polygonal facets.

In each of the embodiments the refractive surfaces comprise convex facets. In a further embodiment shown in use in FIG. **19**, a lens is provided having a plurality of light entering sections, each having an associated light emitting section and an optical lens positioned between each light entering section and the associated light emitting section.

Referring now to FIG. **19**, there is shown a lighting unit is the form of a downlight unit **702** incorporating a terminal block, transformer unit or driver **704** provided on a mounting arm secured at one end to an upper end of the downlight unit **702**.

The downlight unit comprises a light source **706** in the form of a plurality of LEDs mounted to a circuit board **708**, for example an aluminium printed circuit board, the circuit board including control circuitry for the light source **706**, a

heat sink **710** connected to a cylindrical casing, the heat sink **710** being provided to a rear side of the circuit board **708** and a lens arrangement located at a front side of the circuit board **708**.

A brass or copper disc **740** is provided between the circuit board **708** and the heat sink **710**.

The term "cylindrical casing" means conforming approximately to the shape of a hollow cylinder. It will be understood that a misshapen cylinder will work equally well. Similarly, while the embodiments show a generally circular cylindrical tubular body other sections may be used with amendment to the sectional shape of other components.

The heat sink **710** is formed from any suitable material, preferably cast aluminium. The heat sink **710** comprises at a lower end an outer annular portion for location against an upper portion of the cylindrical casing. The annular portion surrounds an end face. In the illustrated embodiment the end face is proud of the annular portion.

The cylindrical casing comprises a mounting ring **714**. The mounting ring **714** comprises a side wall having a lower peripheral annular flange extending outwardly from a bottom end of the side wall and an upper peripheral annular flange extending inwardly from an upper end of the side wall. The mounting ring **714** is formed from any suitable material, preferably steel.

The upper peripheral flange locates against the annular portion of the heat sink **710** and surrounds the end face of the heat sink.

A first ring or washer **716** of silicon is provided on the upper surface of the lower peripheral flange. In use, the ring or washer **716** butts up against a rim of an aperture into which the downlight is fitted.

A bracket **718** incorporating spring biased members or clips **720** is located about the heat sink **710**. The spring biased members or clips **720** are adapted to secure the lighting unit in a recess in a known manner. It can be seen that the driver **704** is secured a central upper region of the bracket **718**. The bracket **718** is secured to the upper peripheral flange of the mounting ring **714** in a suitable fashion, for example by screw fasteners **722**.

The lens arrangement comprises a lens holder **724** and a lens **726** in accordance with the second aspect of the present invention. The lens holder **726** may be of any suitable material, for example a polycarbonate. The lens **724** may be of any suitable material, for example polymethylmethacrylate.

The lens **726** is retained in position relative to the light source **706** by the lens holder **724**. The lens holder **724** comprises a ring or washer having a support structure for engaging and securing the lens **726** to the lens holder **724**, as well as an inwardly directed finger or fingers. The lens **726** is provided with cooperating features to engaging the lens holder **724** and becoming secured to it. The lens holder **724** is secured at its periphery to the upper peripheral flange of the mounting ring **714** in a suitable fashion, for example by utilising the screw fasteners **722** securing the bracket **718** to the mounting ring **714**.

A bezel **730** is fitted to an underside of the mounting ring **14**. The bezel **730** may be of any suitable material, for example cast aluminium. The bezel **730** comprises an inner wall having an inwardly directed shoulder toward a lower end and a radially outwardly directed annular flange at the lower end. The inner wall extends within the side wall of the mounting ring **714**. In use the inner wall of the bezel and the side wall of the mounting ring are provided with cooperating features, such as male and female parts of a bayonet fixing, to enable the bezel **730** to be secured to the mounting ring **714**. In use the inner shoulder supports a glass **732** located in front of the lens **726**. The glass **732** is of any suitable material to allow transmission of the light emitted from the lens **726**.

Preferably a second ring or washer **734** of silicon extends between the radially outwardly directed annular flange of the bezel **30** and the first peripheral flange of the mounting ring **14**.

The circuit board **708** is generally circular and provided with openings by which the circuit board may be located in position. In practice the brass or copper disc **740** is secured about its periphery to the mounting ring **714**. The end face of the heat sink **10** is in thermal contact with a rear face of the brass or copper disc **740**. The circuit board **708** is secured through the brass or copper disc **740** to the heat sink **710** by any suitable means such as fasteners.

A ring or washer **736** of a suitable fireproof material is preferably located between the edge of brass or copper disc **740** and the upper peripheral flange of the mounting ring **714**.

A second embodiment of a downlight unit **802** in accordance with the present invention is shown in FIG. **20**. Similar parts will be referred to by similar reference numerals. The downlight unit **802** comprises a light source **806** mounted to a circuit board **808**, the circuit board including control circuitry for the light source **806**, a heat sink **810** provided to a rear side of the circuit board **808** and a lens arrangement located at a front side of the circuit board. The mounting ring **814** is of like configuration to that of the previous embodiment.

A bracket **818** having depending legs and a central portion is provided in which spring biased members or clips **820** are mounted on each of the legs. Feet at the free ends of the legs are secured to the mounting ring **814**.

A driver **804** is mounted within a driver box in turn located within a recess in the heat sink **810**. The driver box is provided with flanges by which the driver box may be secured to an upper part of the heat sink **810** by any suitable means.

The heat sink **810** is mounted on the mounting ring **814** with a front face of the heat sink **810** being located within an upper annular flange of the mounting ring **814**.

A first ring or washer **816** of silicon is provided on a lower peripheral flange of the mounting ring **814**.

The circuit board **808** is secured to the mounting ring **814** by fasteners **822**, such that the end face of the heat sink **810** is in thermal contact with a rear surface of the circuit board **808**. The fasteners **822** also serve to secure a lens holder in position. The lens holder is used to locate a lens **826** in position.

In this embodiment, the lens holder comprises two parts. A first part **824***a* of the lens holder is secured in place to the upper peripheral flange of the mounting ring **814**. A second part **824***b* of the lens holder retains a periphery of the lens **826** between itself and the first part **824***a* of the lens holder.

A glass **832** retained by a bezel **830**, itself located within and by the mounting ring **814**, is disposed in front of the lens **826** and lens holder. A second ring or washer **834** of silicon extends between the bezel **830** and the mounting ring **814**. A ring or washer **836** of fireproof material is preferably located between the circuit board **808** and the mounting ring **824**.

The invention claimed is:

1. An LED integrated light source lens comprising a light entering section in the shape of a blind recess, a light emitting section at a front face of the lens, an optical lens positioned between the light entering section and the light

emitting section, the optical lens having a substantially solid generally conical or frustoconical body, the external surface of the conical or frustoconical body incorporating a network of densely distributed convex facets that cause the LED integrated light source lens to emit multi-point light beams, wherein the light emitting section comprises a generally cup-shaped recess comprising an inclined surface extending inwardly from the front face of the lens the inclined surface being concave, and the inclined surface meeting a base provided with a network of refractive surfaces.

2. The integrated light source lens according to claim **1**, wherein the blind recess has a circular opening.

3. The LED integrated light source lens according to claim **1**, comprising a plurality of light entering sections, each in the shape of a blind recess, a plurality of light emitting sections, and, incorporating an optical lens positioned between each light entering section and the associated light emitting section.

4. The integrated light source lens according to claim **3**, wherein each blind recess is provided with a non-spherical surface at its base.

5. A downlight comprising a casing, an LED light source, an LED integrated light source lens according to claim **1**, a lens holder and a heat sink.

6. The downlight according to claim **5**, the downlight further comprising a glass and retaining means for the glass.

7. The downlight according to claim **5**, wherein the light source comprises one or more LEDs mounted on a circuit board.

8. The downlight according to claim **7**, wherein the circuit board is formed of a ceramic material.

9. The downlight according to claim **7**, wherein the circuit board is formed of aluminium and a brass or copper disc is located between the circuit board and the heat sink.

10. The LED integrated light source lens according to claim **1**, wherein the base of the light emitting section is generally circular.

11. The LED integrated light source lens according to claim **1**, wherein the base of the light emitting section is convex in shape.

12. The LED integrated light source lens according to claim **1**, wherein the network of refractive surfaces in the base of the light emitting section comprises densely distributed convex facets.

13. The LED integrated light source lens according to claim **1** wherein the blind recess is circular in section.

14. The LED integrated light source lens according to claim **1** wherein the blind recess is hexagonal in cross-section.

15. The LED integrated light source lens according to claim **1** wherein the base of the blind recess is provided with a refractive surface.

16. The LED integrated light source lens according to claim **15** wherein the refractive surface takes the form of a hexagonal pattern of convex facets formed on the surface of the base of the blind recess.

17. The LED integrated light source lens according to claim **15** wherein the refractive surface is a non-spherical refractive surface.

18. The LED integrated light source lens according to claim **15** wherein the refractive surface is located on a generally level plane.

19. The LED integrated light source lens according to claim **1** wherein the light entering section, the light emitting section, and the optical lens body are formed as a unitary or one piece body.

20. The LED integrated light source lens as in any of the preceding claims wherein the lens is formed from a transparent plastics material.

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